



US011849801B2

(12) **United States Patent**  
**Chan et al.**

(10) **Patent No.:** **US 11,849,801 B2**  
(45) **Date of Patent:** **\*Dec. 26, 2023**

(54) **AIRBAG FOR ARTICLE OF FOOTWEAR**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.  
  
This patent is subject to a terminal disclaimer.

(21) Appl. No.: **17/734,717**

(22) Filed: **May 2, 2022**

(65) **Prior Publication Data**

US 2022/0248801 A1 Aug. 11, 2022

**Related U.S. Application Data**

(63) Continuation of application No. 17/133,732, filed on Dec. 24, 2020.  
(Continued)

(51) **Int. Cl.**  
**A43B 13/18** (2006.01)  
**A43B 13/20** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **A43B 13/186** (2013.01); **A43B 7/1415** (2013.01); **A43B 13/127** (2013.01); **A43B 13/188** (2013.01); **A43B 13/206** (2013.01)

(58) **Field of Classification Search**  
CPC ... **A43B 13/186**; **A43B 13/127**; **A43B 13/188**;  
**A43B 13/206**; **A43B 13/20**;  
(Continued)

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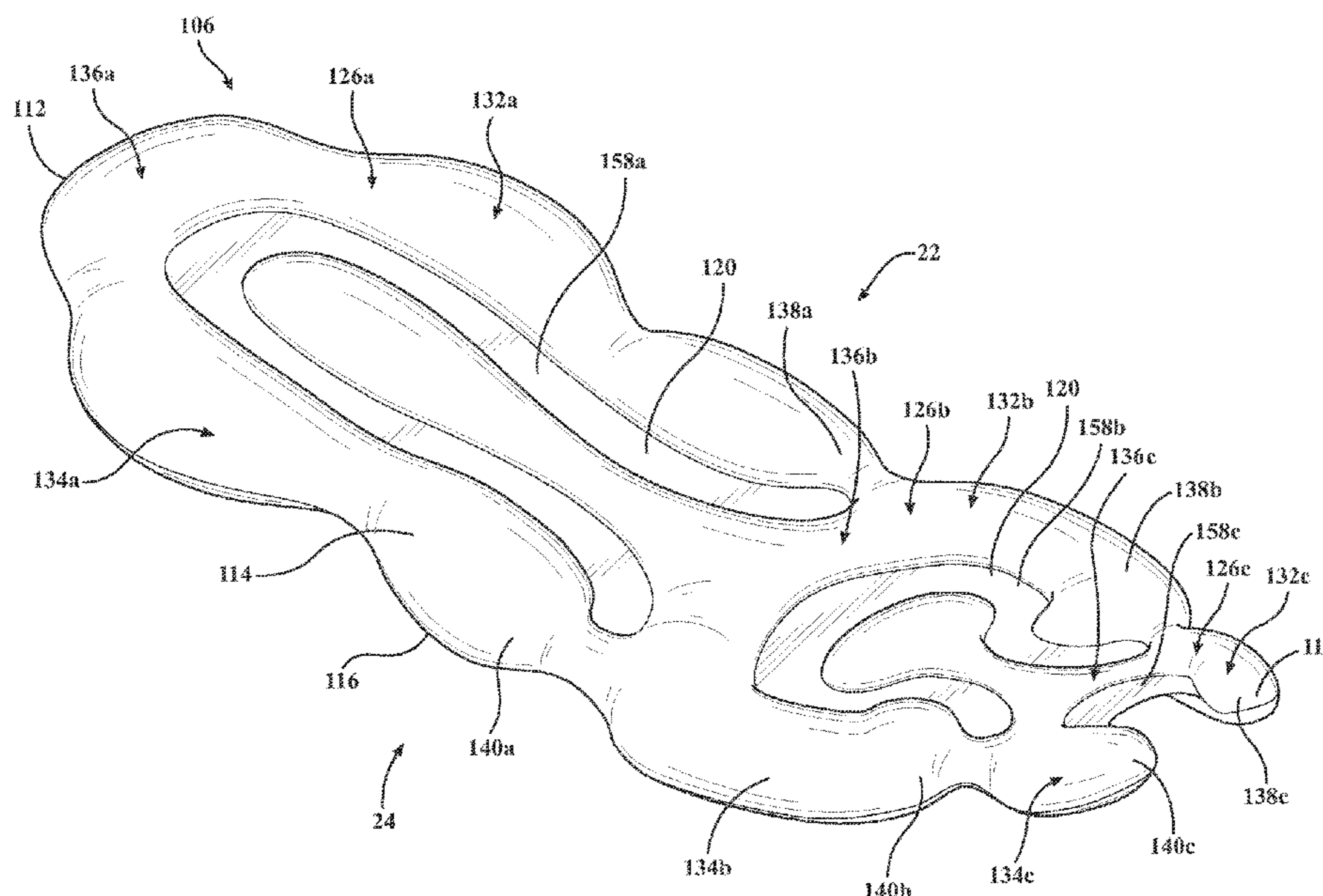
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(57) **ABSTRACT**

A fluid-filled chamber includes first subchamber having a substantially U-shape. The fluid-filled chamber also includes a second subchamber having a substantially U-shape and being spaced apart from the first subchamber in a direction extending along a longitudinal axis of the fluid-filled chamber.

**17 Claims, 6 Drawing Sheets**



**Related U.S. Application Data**

- (60) Provisional application No. 62/955,120, filed on Dec. 30, 2019.
- (51) **Int. Cl.**  
*A43B 7/1415* (2022.01)  
*A43B 13/12* (2006.01)
- (58) **Field of Classification Search**  
 CPC ... A43B 13/189; A43B 13/203; A43B 3/0063;  
 A43B 7/141; A43B 7/1415  
 USPC ..... 36/29; 428/34.1  
 See application file for complete search history.

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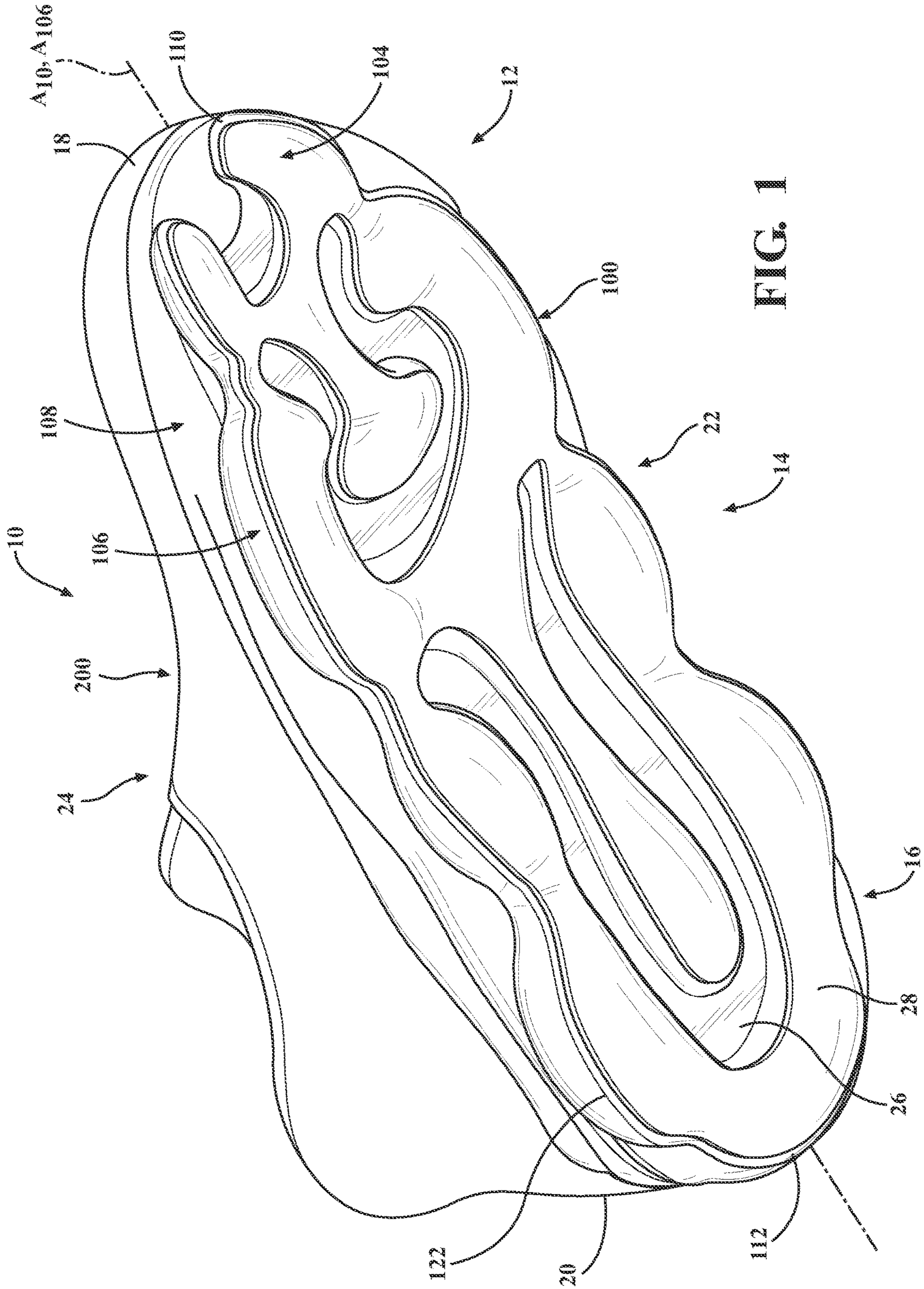


FIG. 1

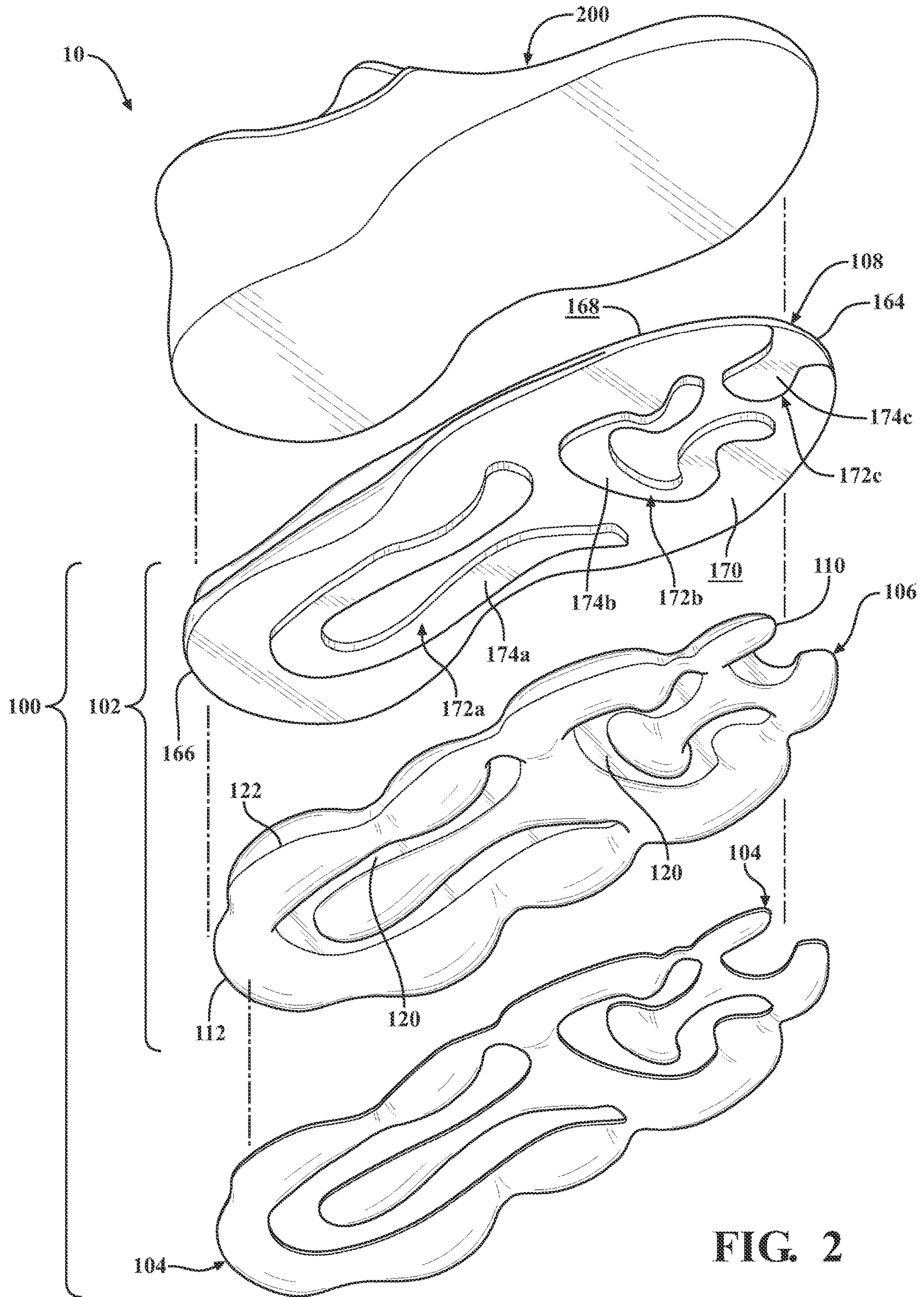


FIG. 2



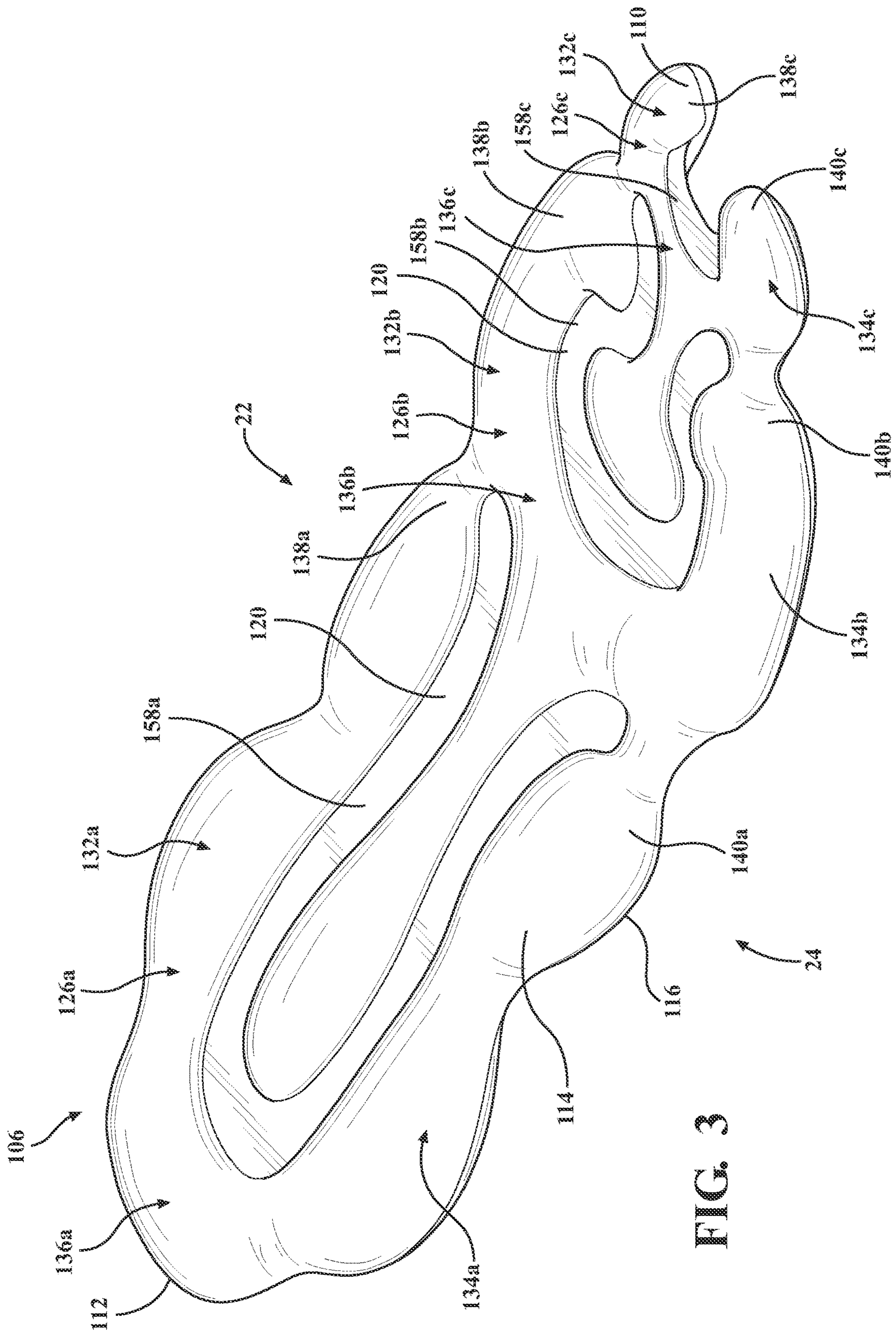


FIG. 3

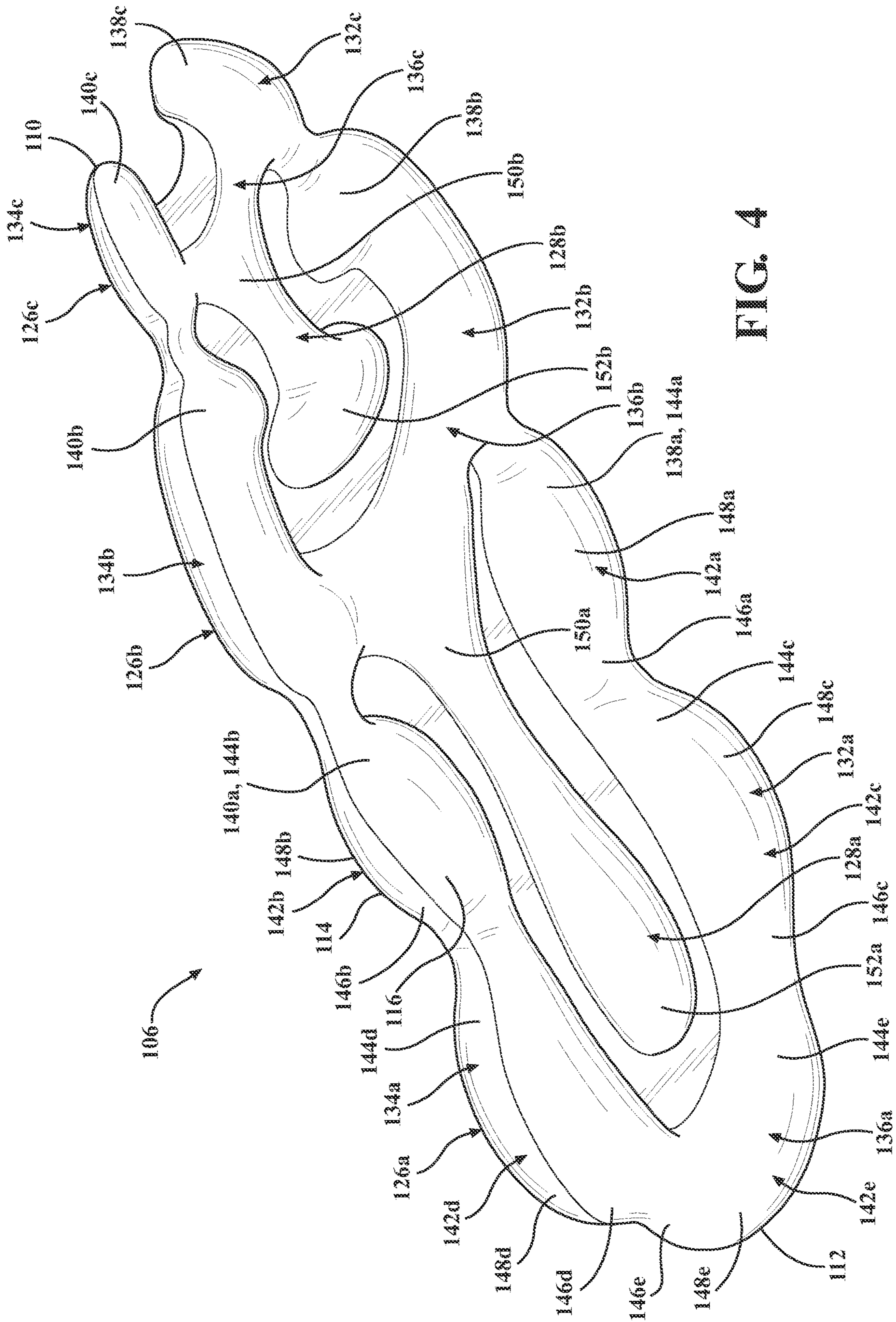
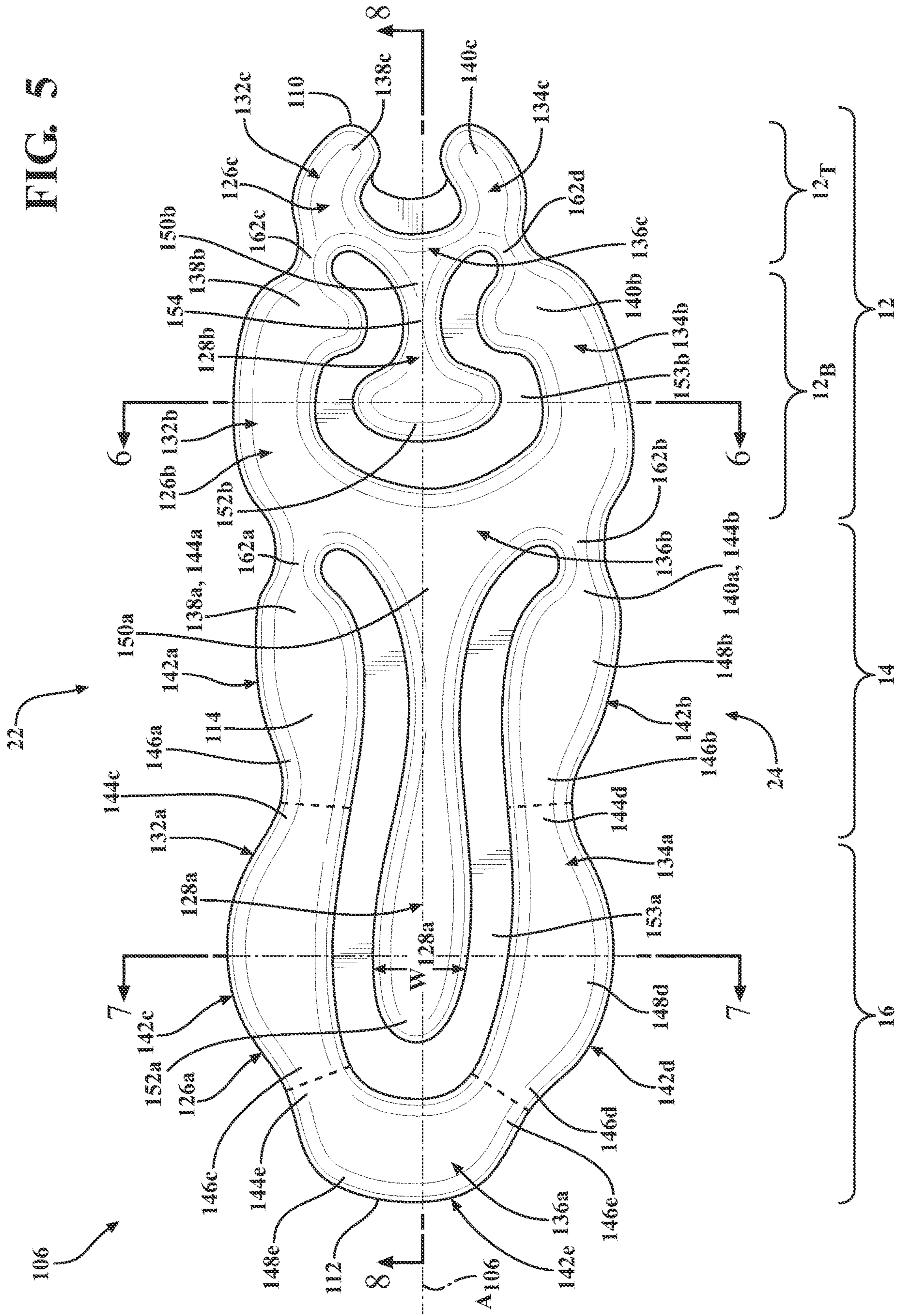
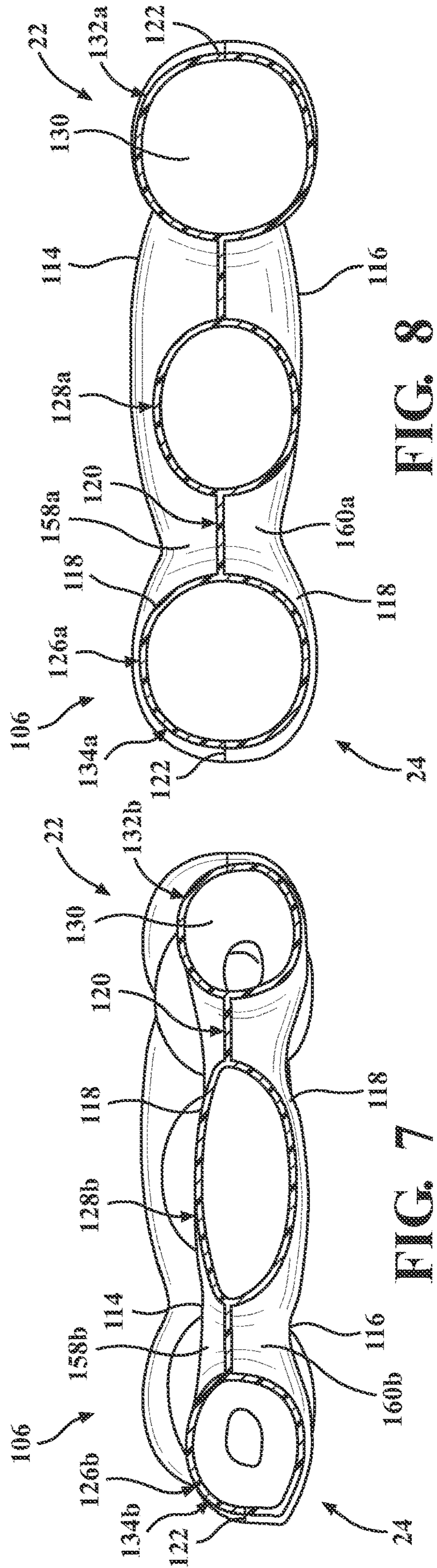
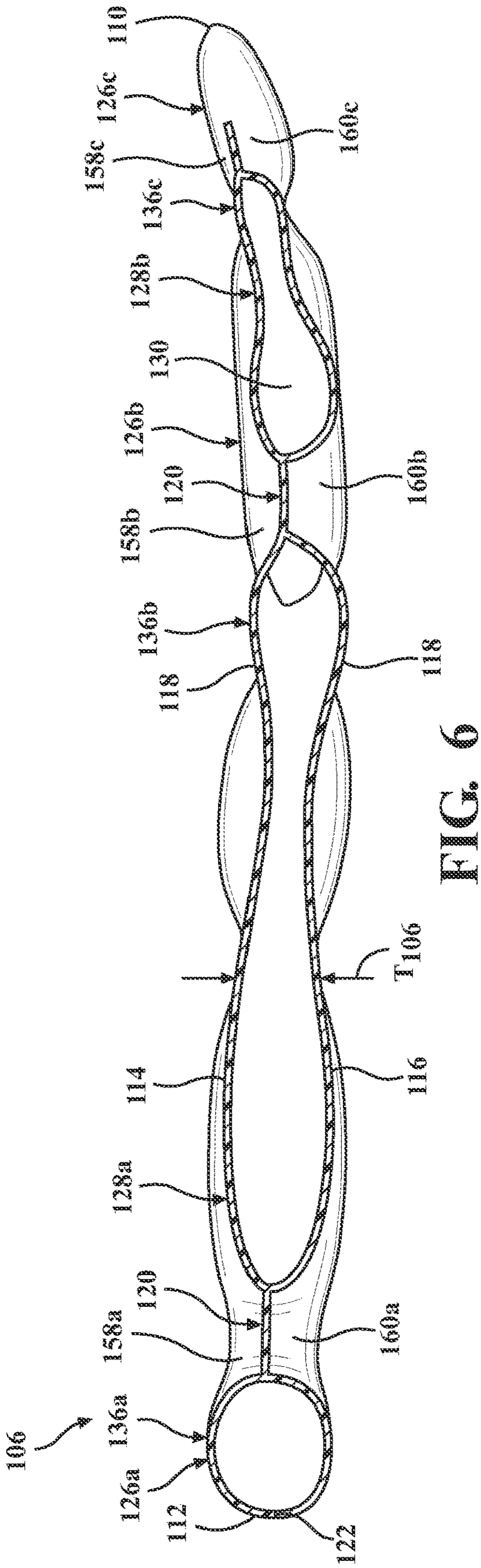


FIG. 4



FIG. 5







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**AIRBAG FOR ARTICLE OF FOOTWEAR****CROSS REFERENCE TO RELATED APPLICATION**

This application is a continuation of U.S. patent application Ser. No. 17/133,732, filed Dec. 24, 2020, which claims priority under 35 U.S.C. § 119(e) to Provisional U.S. Patent Application No. 62/955,120, filed Dec. 30, 2019, the disclosures of which are hereby incorporated by reference in their entireties.

**FIELD**

The present disclosure relates generally to sole structures for articles of footwear, and more particularly, to sole structures incorporating a fluid-filled bladder.

**BACKGROUND**

This section provides background information related to the present disclosure which is not necessarily prior art.

Articles of footwear conventionally include an upper and a sole structure. The upper may be formed from any suitable material(s) to receive, secure, and support a foot on the sole structure. The upper may cooperate with laces, straps, or other fasteners to adjust the fit of the upper around the foot. A bottom portion of the upper, proximate to a bottom surface of the foot, attaches to the sole structure.

Sole structures generally include a layered arrangement extending between a ground surface and the upper. One layer of the sole structure includes an outsole that provides abrasion-resistance and traction with the ground surface. The outsole may be formed from rubber or other materials that impart durability and wear-resistance, as well as enhance traction with the ground surface. Another layer of the sole structure includes a midsole disposed between the outsole and the upper. The midsole provides cushioning for the foot and may be partially formed from a polymer foam material that compresses resiliently under an applied load to cushion the foot by attenuating ground-reaction forces. The midsole may additionally or alternatively incorporate a fluid-filled bladder to increase durability of the sole structure, as well as to provide cushioning to the foot by compressing resiliently under an applied load to attenuate ground-reaction forces. Sole structures may also include a comfort-enhancing insole or a sockliner located within a void proximate to the bottom portion of the upper and a strobrel attached to the upper and disposed between the midsole and the insole or sockliner.

Midsoles employing fluid-filled bladders typically include a bladder formed from two barrier layers of polymer material that are sealed or bonded together. The fluid-filled bladders are pressurized with a fluid such as air, and may incorporate tensile members within the bladder to retain the shape of the bladder when compressed resiliently under applied loads, such as during athletic movements. Generally, bladders are designed with an emphasis on balancing support for the foot and cushioning characteristics that relate to responsiveness as the bladder resiliently compresses under an applied load

**DRAWINGS**

The drawings described herein are for illustrative purposes only of selected configurations and are not intended to limit the scope of the present disclosure.

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FIG. 1 is a perspective view of an article of footwear in accordance with principles of the present disclosure;

FIG. 2 is an exploded view of the article of footwear of FIG. 1, showing an article of footwear having an upper and a sole structure arranged in a layered configuration;

FIG. 3 is a top perspective view of a bladder in accordance with the principles of the present disclosure for use with the article of footwear of FIG. 1;

FIG. 4 is a bottom perspective view of a bladder in accordance with the principles of the present disclosure for use with the article of footwear of FIG. 1;

FIG. 5 is a bottom plan view of a bladder in accordance with the principles of the present disclosure for use with the article of footwear of FIG. 1

FIG. 6 is a cross-sectional view of the bladder of FIG. 3 taken along Line 6-6 of FIG. 5;

FIG. 7 is a cross-sectional view of the bladder of FIG. 3 taken along Line 7-7 of FIG. 5; and

FIG. 8 is a cross-sectional view of the bladder of FIG. 3 taken along Line 8-8 of FIG. 5.

Corresponding reference numerals indicate corresponding parts throughout the drawings.

**DETAILED DESCRIPTION**

Example configurations will now be described more fully with reference to the accompanying drawings. Example configurations are provided so that this disclosure will be thorough, and will fully convey the scope of the disclosure to those of ordinary skill in the art. Specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of configurations of the present disclosure. It will be apparent to those of ordinary skill in the art that specific details need not be employed, that example configurations may be embodied in many different forms, and that the specific details and the example configurations should not be construed to limit the scope of the disclosure.

The terminology used herein is for the purpose of describing particular exemplary configurations only and is not intended to be limiting. As used herein, the singular articles “a,” “an,” and “the” may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises,” “comprising,” “including,” and “having,” are inclusive and therefore specify the presence of features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. Additional or alternative steps may be employed.

When an element or layer is referred to as being “on,” “engaged to,” “connected to,” “attached to,” or “coupled to” another element or layer, it may be directly on, engaged, connected, attached, or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being “directly on,” “directly engaged to,” “directly connected to,” “directly attached to,” or “directly coupled to” another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., “between” versus “directly between,” “adjacent” versus



“directly adjacent,” etc.). As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

The terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections. These elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as “first,” “second,” and other numerical terms do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example configurations.

One aspect of the disclosure provides a bladder. The bladder includes a first chamber having a substantially U-shape. The bladder also includes a second chamber having a substantially U-shape and being spaced apart from the first chamber in a direction extending along a longitudinal axis of the bladder.

Implementations of the disclosure may include one or more of the following optional features. In some implementations, the first chamber and the second chamber are in fluid communication with one another. The first chamber may be aligned with the second chamber.

In some examples, the first chamber includes a first leg and a second leg joined by a first arcuate segment and the second chamber includes a third leg and a fourth leg joined by a second arcuate segment. The first leg, the second leg, the third leg, and the fourth leg may extend in the same direction. The first leg and the second leg may be disposed between the first arcuate segment and the second arcuate segment. At least one of the first leg, the second leg, the third leg, and the fourth leg may be elongate. The bladder may include a third chamber extending between the first leg and the second leg in a direction toward the first arcuate segment. The third chamber may be spaced apart from the first leg and the second leg. The bladder may include a fourth chamber extending between the third leg and the fourth leg in a direction toward the second arcuate segment. The fourth chamber may be spaced apart from the third leg and the fourth leg. At least one of the third chamber and the fourth chamber may be elongate.

In some configurations, the bladder includes a web area defining the first chamber and the second chamber. The web area may include a first portion having a substantially U-shape and a second portion having a substantially U-shape. An article of footwear may incorporate the bladder.

Another aspect of the disclosure provides a bladder. The bladder includes a first chamber and a second chamber spaced apart from the first chamber in a direction extending along a longitudinal axis of the bladder. The bladder also includes a web area defining the first chamber and the second chamber and including a first portion having a substantially U-shape and a second portion having a substantially U-shape.

Implementations of the disclosure may include one or more of the following optional features. In some implementations, the first chamber and the second chamber are in fluid communication with one another. The first chamber may include a substantially U-shape and the second chamber may include a substantially U-shape. Here, the first chamber is aligned with the second chamber.

In some examples, the first chamber includes a first leg and a second leg joined by a first arcuate segment, and the second chamber includes a third leg and a fourth leg joined

by a second arcuate segment. Here, the first leg, the second leg, the third leg, and the fourth leg may extend in the same direction. Optionally, the first leg and the second leg may be disposed between the first arcuate segment and the second arcuate segment. At least one of the first leg, the second leg, the third leg, and the fourth leg may be elongate. The bladder may include a third chamber extending between the first leg and the second leg in a direction toward the first arcuate segment. Here, the third chamber may be spaced apart from the first leg and the second leg. Optionally, the bladder may include a fourth chamber extending between the third leg and the fourth leg in a direction toward the second arcuate segment. The fourth chamber may be spaced apart from the third leg and the fourth leg. At least one of the third chamber and the fourth chamber may be elongate. An article of footwear may incorporate the bladder.

Referring to FIGS. 1-8, an article of footwear **10** includes a sole structure **100** and an upper **200** attached to the sole structure **100**. The article of footwear **10** may be divided into one or more regions. The regions may include a forefoot region **12**, a mid-foot region **14**, and a heel region **16**. The forefoot region **12** may be further described as including a toe portion **12T** corresponding to the phalanges of the foot, and a ball portion **12B** corresponding to a metatarsophalangeal (MTP) joint. The mid-foot region **14** may correspond with an arch area of the foot, and the heel region **16** may correspond with rear portions of the foot, including a calcaneus bone. The footwear **10** may further include an anterior end **18** associated with a forward-most point of the forefoot region **12**, and a posterior end **20** corresponding to a rearward-most point of the heel region **16**. A longitudinal axis  $A_{10}$  of the footwear **10** extends along a length of the footwear **10** from the anterior end **18** to the posterior end **20**, and generally divides the footwear **10** into a medial side **22** and a lateral side **24**, as shown in FIG. 1. Accordingly, the medial side **22** and the lateral side **24** respectively correspond with opposite sides of the footwear **10** and extend through the regions **12**, **14**, **16**.

The article of footwear **10**, and more particularly, the sole structure **100**, may be further described as including an interior region **26** and a peripheral region **28**, as indicated in FIG. 1. The peripheral region **28** is generally described as being a region between the interior region **26** and an outer perimeter of the sole structure **100**. Particularly, the peripheral region **28** extends from the forefoot region **12** to the heel region **16** along each of the medial side **22** and the lateral side **24**, and wraps around each of the forefoot region **12** and the heel region **16**. Thus, the interior region **26** is circumscribed by the peripheral region **28**, and extends from the forefoot region **12** to the heel region **16** along a central portion of the sole structure **100**.

With reference to FIG. 2, the sole structure **100** includes a midsole **102** configured to provide cushioning characteristics to the sole structure **100**, and an outsole **104** configured to provide a ground-engaging surface of the article of footwear **10**. Unlike conventional sole structures, the midsole **102** of the sole structure **100** may be formed compositely and include a plurality of subcomponents for providing desired forms of cushioning and support throughout the sole structure **100**. For example, the midsole **102** includes a bladder **106** and a chassis **108**, where the chassis **108** is attached to the upper **200** and provides an interface between the upper **200** and the bladder **106**.

With reference to FIGS. 1-5, a longitudinal axis  $A_{106}$  of the bladder **106** extends from a first end **110** in the forefoot region **12** to a second end **112** in the heel region **16**. The bladder **106** may be further described as including a top



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surface or side **114** and a bottom surface or side **116** formed on an opposite side of the bladder **106** from the top side **114**. As discussed in greater detail below with respect to FIGS. **6-8**, a thicknesses  $T_{106}$  of the bladder **106**, or of elements of the bladder **106**, are defined by a distance from the top side **114** to the bottom side **116**.

As shown in the cross-sectional views of FIGS. **6-8**, the bladder **106** may be formed by an opposing pair of barrier layers **118**, which can be joined to each other at discrete locations to define an overall shape of the bladder **106**. Alternatively, the bladder **106** can be produced from any suitable combination of one or more barrier layers. As used herein, the term “barrier layer” (e.g., barrier layers **118**) encompasses both monolayer and multilayer films. In some embodiments, one or both of the barrier layers **118** are each produced (e.g., thermoformed or blow molded) from a monolayer film (a single layer). In other embodiments, one or both of the barrier layers **118** are each produced (e.g., thermoformed or blow molded) from a multilayer film (multiple sublayers). In either aspect, each layer or sublayer can have a film thickness ranging from about 0.2 micrometers to about 1 millimeter. In further embodiments, the film thickness for each layer or sublayer can range from about 0.5 micrometers to about 500 micrometers. In yet further embodiments, the film thickness for each layer or sublayer can range from about 1 micrometer to about 100 micrometers.

One or both of the barrier layers **118** can independently be transparent, translucent, and/or opaque. As used herein, the term “transparent” for a barrier layer and/or a bladder means that light passes through the barrier layer in substantially straight lines and a viewer can see through the barrier layer. In comparison, for an opaque barrier layer, light does not pass through the barrier layer and one cannot see clearly through the barrier layer at all. A translucent barrier layer falls between a transparent barrier layer and an opaque barrier layer, in that light passes through a translucent layer but some of the light is scattered so that a viewer cannot see clearly through the layer.

The barrier layers **118** can each be produced from an elastomeric material that includes one or more thermoplastic polymers and/or one or more cross-linkable polymers. In an aspect, the elastomeric material can include one or more thermoplastic elastomeric materials, such as one or more thermoplastic polyurethane (TPU) copolymers, one or more ethylene-vinyl alcohol (EVOH) copolymers, and the like.

As used herein, “polyurethane” refers to a copolymer (including oligomers) that contains a urethane group ( $-\text{N}(\text{C}=\text{O})\text{O}-$ ). These polyurethanes can contain additional groups such as ester, ether, urea, allophanate, biuret, carbodiimide, oxazolidinyl, isocyanurate, uretdione, carbonate, and the like, in addition to urethane groups. In an aspect, one or more of the polyurethanes can be produced by polymerizing one or more isocyanates with one or more polyols to produce copolymer chains having ( $-\text{N}(\text{C}=\text{O})\text{O}-$ ) linkages.

Examples of suitable isocyanates for producing the polyurethane copolymer chains include diisocyanates, such as aromatic diisocyanates, aliphatic diisocyanates, and combinations thereof. Examples of suitable aromatic diisocyanates include toluene diisocyanate (TDI), TDI adducts with trimethylolpropane (TMP), methylene diphenyl diisocyanate (MDI), xylene diisocyanate (XDI), tetramethylxylylene diisocyanate (TMXDI), hydrogenated xylene diisocyanate (HXDI), naphthalene 1,5-diisocyanate (NDI), 1,5-tetrahydronaphthalene diisocyanate, para-phenylene diisocyanate (PPDI), 3,3'-dimethyldiphenyl-4, 4'-diisocyanate (DDDI),

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4,4'-dibenzyl diisocyanate (DBDI), 4-chloro-1,3-phenylene diisocyanate, and combinations thereof. In some embodiments, the copolymer chains are substantially free of aromatic groups.

In particular aspects, the polyurethane polymer chains are produced from diisocyanates including HMDI, TDI, MDI, H12 aliphatics, and combinations thereof. In an aspect, the thermoplastic TPU can include polyester-based TPU, polyether-based TPU, polycaprolactone-based TPU, polycarbonate-based TPU, polysiloxane-based TPU, or combinations thereof.

In another aspect, the polymeric layer can be formed of one or more of the following: EVOH copolymers, poly(vinyl chloride), polyvinylidene polymers and copolymers (e.g., polyvinylidene chloride), polyamides (e.g., amorphous polyamides), amide-based copolymers, acrylonitrile polymers (e.g., acrylonitrile-methyl acrylate copolymers), polyethylene terephthalate, polyether imides, polyacrylic imides, and other polymeric materials known to have relatively low gas transmission rates. Blends of these materials, as well as with the TPU copolymers described herein and optionally including combinations of polyimides and crystalline polymers, are also suitable.

The barrier layers **118** may include two or more sublayers (multilayer film) such as shown in Mitchell et al., U.S. Pat. No. 5,713,141 and Mitchell et al., U.S. Pat. No. 5,952,065, the disclosures of which are incorporated by reference in their entireties. In embodiments where the barrier layers **118** include two or more sublayers, examples of suitable multilayer films include microlayer films, such as those disclosed in Bonk et al., U.S. Pat. No. 6,582,786, which is incorporated by reference in its entirety. In further embodiments, the barrier layers **118** may each independently include alternating sublayers of one or more TPU copolymer materials and one or more EVOH copolymer materials, where the total number of sublayers in each of the barrier layers **118** includes at least four (4) sublayers, at least ten (10) sublayers, at least twenty (20) sublayers, at least forty (40) sublayers, and/or at least sixty (60) sublayers.

The bladder **106** can be produced from the barrier layers **118** using any suitable technique, such as thermoforming (e.g. vacuum thermoforming), blow molding, extrusion, injection molding, vacuum molding, rotary molding, transfer molding, pressure forming, heat sealing, casting, low-pressure casting, spin casting, reaction injection molding, radio frequency (RF) welding, and the like. In an aspect, the barrier layers **118** can be produced by co-extrusion followed by vacuum thermoforming to form the profile of the bladder **106**, which can optionally include one or more valves **121** (e.g., one way valves) that allows the bladder **106** to be filled with the fluid (e.g., gas).

The bladder **106** desirably has a low gas transmission rate to preserve its retained gas pressure. In some embodiments, the bladder **106** has a gas transmission rate for nitrogen gas that is at least about ten (10) times lower than a nitrogen gas transmission rate for a butyl rubber layer of substantially the same dimensions. In an aspect, bladder **106** has a nitrogen gas transmission rate of 15 cubic-centimeter/square-meter-atmosphere-day ( $\text{cm}^3/\text{m}^2\cdot\text{atm}\cdot\text{day}$ ) or less for an average film thickness of 500 micrometers (based on thicknesses of barrier layers **118**). In further aspects, the transmission rate is 10  $\text{cm}^3/\text{m}^2\cdot\text{atm}\cdot\text{day}$  or less, 5  $\text{cm}^3/\text{m}^2\cdot\text{atm}\cdot\text{day}$  or less, or 1  $\text{cm}^3/\text{m}^2\cdot\text{atm}\cdot\text{day}$  or less.

In the shown embodiment, the barrier layers **118** include a first, upper barrier layer **118** forming the top side **114** of the bladder **106**, and a second, lower barrier layer **118** forming the bottom side **116** of the bladder **106**. In the illustrated



example, interior, opposing surfaces (i.e. facing each other) of the barrier layers 118 are joined together at discrete locations to form a web area 120 and a peripheral seam 122. The peripheral seam 122 extends around the outer periphery of the bladder 106 and defines an outer peripheral profile of the bladder 106. As shown in FIGS. 3-8, the upper and lower barrier layers 118 are spaced apart from each other between the web area 120 and the peripheral seam 122 to define a plurality of chambers 126a-126c, 128a-128b each forming a respective portion of an interior void 130 of the bladder 106.

In the illustrated example, the bladder 106 includes a plurality of U-shaped or horseshoe-shaped chambers 126a-126c. As discussed in greater detail below, portions of these chambers 126a-126c extend along the medial and lateral sides 22, 24 in the peripheral region 28. Accordingly, these chambers 126a-126b may be referred to as peripheral chambers 126a-126c. The peripheral chambers 126a-126c include a heel peripheral chamber 126a, a forefoot peripheral chamber 126b, and a toe peripheral chamber 126c, where the forefoot peripheral chamber 126b is disposed between the heel peripheral chamber 126a and the toe peripheral chamber 126c and is smaller than the heel peripheral chamber 126a and larger than the toe peripheral chamber 126c. Generally, the peripheral chambers 126a-126c are arranged in series along the longitudinal axis  $A_{106}$  from the first end 110 of the bladder 106 to the second end 112 of the bladder 106. Accordingly, the chambers 126a-126c are aligned with each other along the direction of the length of the bladder 106.

Each of the peripheral chambers 126a-126c may be described as including a medial elongate segment or leg 132a-132c extending along the medial side 22 of the bladder 106 in the peripheral region 28, a lateral elongate segment or leg 134a-134c extending along the lateral side 24 of the bladder 106 in the peripheral region 28, and an intermediate segment 136a-136c extending across the interior region 26 and connecting the medial leg 132a-132c to the lateral leg 134a-134c. As shown, the intermediate segment 136a-136c of each of the peripheral chambers 126a-126c may extend along an arcuate path from the medial side 22 to the lateral side 24. Here, each of the medial legs 132a-132c extends from the respective intermediate segment 136a-136c in a direction along the longitudinal axis  $A_{106}$  to a medial end 138a-138c on the medial side 22 of the bladder 106, and each of the lateral legs 134a-134c extends from the respective intermediate segment 136a-136c in a direction along the longitudinal axis  $A_{106}$  to a lateral end 140a-140c on the lateral side 24 of the bladder 106. Thus, the respective medial legs 132a-132c and the lateral legs 134a-134c extend along the same direction from opposite ends of the intermediate segments 136a-136c.

With reference to FIGS. 3-5, the heel peripheral chamber 126a extends through the mid-foot and heel regions 14, 16 of the bladder 106 in the peripheral region 28. Particularly, the heel peripheral chamber 126a includes the medial leg 132a extending along the medial side 22 from the medial end 138a adjacent to the forefoot region 14, and the lateral leg 134a extending along the lateral side 24 from the lateral end 140a adjacent to the forefoot region 14. The intermediate segment 136c extends around the second end 112 of the bladder 106 from the medial leg 132a to the lateral leg 134a. As discussed in greater detail below, the medial and lateral ends 138a, 140a of the heel peripheral chamber 126a may each be in direct fluid communication with the forefoot peripheral chamber 126b. In other words, the ends 138a, 140a may each be directly connected to the forefoot peripheral chamber 126b.

Referring to FIGS. 4 and 5, one or more of the peripheral chambers 126a-126c may have a variable cross-sectional area from end to end. As shown, the heel peripheral chamber 126a includes a plurality of lobes 142a-142e each forming a portion of the heel peripheral chamber 126a having a variable cross-sectional area. For example, each of the lobes 142a-142e includes a first end 144a-144e having a first cross-sectional area, a second end 146a-146e having a second cross-sectional area, and an intermediate portion 148a-148e disposed between the first end 144a-144e and the second end 146a-146e and having a third cross-sectional area that is greater than the first cross-sectional area and the second cross-sectional area. Accordingly, each of the lobes 142a-142e tapers towards the respective first end 144a-144e and second end 146a-146e from the intermediate portion 148a-148e. In some examples, both the width and the thickness of each of the lobes 142a-142e tapers from the intermediate portion 148a-148e.

The illustrated example of the bladder 106 includes a plurality of the lobes 142a-142e arranged end-to-end in series along the peripheral region 28 such that the cross-sectional area of the heel peripheral chamber 126a alternates between larger and smaller sizes. As shown, the plurality of the lobes 142a-142e includes a first pair of anterior lobes 142a, 142b at the ends 138a, 140a of the heel peripheral chamber 126a, a pair of intermediate lobes 142c, 142d disposed between the anterior lobes 142a, 142b and the second end 112, and a posterior lobe 142e disposed at the second end 112 of the bladder 106.

The anterior lobes 142a, 142b of the heel peripheral chamber 126a include a medial anterior lobe 142a disposed at the medial end 138a on the medial side 22 of the bladder 106, and a lateral anterior lobe 142b disposed at the lateral end 140a on the lateral side 24 of the bladder 106. Each of the anterior lobes 142a, 142b extends from its respective first end 144a, 144b and along the peripheral region 28 to its respective second end 146a, 146b.

With continued reference to FIGS. 3-5, the posterior lobe 142e is disposed at the second end 112 of the bladder 106 and the intermediate portion 148e of the posterior lobe 142e is aligned with the longitudinal axis  $A_{106}$  of the bladder 106. In the illustrated example, the posterior lobe 142e extends from a first end 144e on the medial side 22 of the bladder 106 to a second end 146e on the lateral side 24 of the bladder 106. As discussed above, the intermediate portion 148e has a greater cross-sectional area than each of the ends 144e, 146e.

The intermediate lobes 142c, 142d of the heel peripheral chamber 126a include a medial intermediate lobe 142c disposed on the medial side 22 of the bladder 106, and a lateral intermediate lobe 142d disposed on the lateral side 24 of the bladder 106. As shown, first ends 144c, 144d of the intermediate lobes 142c, 142d are connected to the second ends 146a, 146b of the medial and lateral anterior lobes 142a, 142b, respectively. The second end 146c of the medial intermediate lobe 142c is connected to the first end 144e of the posterior lobe 142e. Likewise, the second end 146d of the lateral intermediate lobe 142d is connected to the second end 146e of the posterior lobe 142e. Similar to the anterior lobes 142a, 142b and the posterior lobe 142e, the intermediate lobes 142c, 142d provide the heel peripheral chamber 126a with protruding portions along the medial and lateral sides 22, 24 of the bladder 106.

Referring still to FIGS. 3-5, the forefoot peripheral chamber 126b extends through the ball portion 12B of the forefoot region 12, and is disposed between the heel peripheral chamber 126a and the toe peripheral chamber 126c. Here,



the medial leg **132b** extends along the medial side **22** from the medial end **138b** adjacent to the toe portion **12T**, and the lateral leg **134b** extends along the lateral side **24** from the lateral end **140b** adjacent to the toe portion **12T**. The intermediate segment **136b** extends across the width of the bladder **106** adjacent to the mid-foot region **14** and connects the medial leg **132b** to the lateral leg **134b**. As shown, the intermediate segment **136b** extends along an arcuate path from the medial side **22** to the lateral side **24**.

In some examples, one or both of the ends **138b**, **140b** of the forefoot peripheral chamber **126b** may be bulbous, whereby a size (e.g., cross-section, width, thickness) of the end **138b**, **140b** is greater than the immediately adjacent portion of the forefoot peripheral chamber **126b**. For example, in the illustrated configuration, a width of each of the ends **138b**, **140b** protrudes inwardly towards the longitudinal axis  $A_{106}$  of the bladder **106**.

With continued reference to FIGS. 3-5, the toe peripheral chamber **126c** extends through the toe portion **12T** of the forefoot region **12**, and is disposed adjacent to the first end **110** of the bladder **106**. Here, the medial leg **132c** extends along the medial side **22** from the medial end **138c** at the first end **110** of the bladder **106**, and the lateral leg **134c** extends along the lateral side **24** from the lateral end **140c** at the first end **110** of the bladder **106**. The intermediate segment **136c** extends across the width of the bladder **106** adjacent to the ball portion **12B** and connects the medial leg **132c** to the lateral leg **134c**. The intermediate segment **136c** extends along an arcuate path from the medial side **22** to the lateral side **24**.

Unlike the heel peripheral chamber **126a** and the forefoot peripheral chamber **126b**, which are fully attached to the web area **120**, the medial and lateral legs **132c**, **134c** of the toe peripheral chamber **126c** may only be partially attached to the web area **120**. For example, the medial and lateral ends **138c**, **140c** of the toe peripheral chamber **126c** may project beyond the web area **120**, such that each of the ends **138c**, **140c** is free-hanging. Accordingly, each of the ends **138c**, **140c** may move independent of the other. In another configuration, the ends **138c**, **140c** may be joined, thereby providing the toe peripheral chamber **126c** with a substantially circular shape (not shown).

In addition to the peripheral chambers **126a-126c**, the bladder **106** includes one or more interior chambers **128a**, **128b** disposed in the interior region **26** of the bladder **106**. Here, each of the interior chambers **128a**, **128b** is at least partially surrounded by a respective one of the peripheral chambers **126a**, **126b**. Generally, each of the interior chambers **128a**, **128b** extends from a first end **150a**, **150b** connected to an intermediate segment **136b**, **136c** of an adjacent one of the peripheral chambers **126b**, **126c**, to a terminal second end **152a**, **152b** adjacent to the intermediate segment **136a**, **136b** of the respective one of the peripheral chambers **126a**, **126b**.

As shown in FIG. 5, a heel interior chamber **128a** extends along the longitudinal axis  $A_{106}$  from a first end **150a** connected to the intermediate segment **136b** of the forefoot peripheral chamber **126b**, to a terminal second end **152a** adjacent to the intermediate segment **136a** of the heel peripheral chamber **126a**. An outer perimeter of the heel interior chamber **128a** is inwardly offset from an inner perimeter of the heel peripheral chamber **126a** by a substantially constant distance. As such, a width of the heel interior chamber **128a** may increase along the direction from the first end **150a** to the second end **152a**.

A forefoot interior chamber **128b** extends along the longitudinal axis  $A_{106}$  from a first end **150b** connected to the

intermediate segment **136c** of the toe peripheral chamber **126c**, to a terminal second end **152b** adjacent to the intermediate segment **136b** of the forefoot peripheral chamber **126b**. As shown, an outer perimeter of the forefoot interior chamber **128b** is inwardly offset from an inner perimeter of the forefoot peripheral chamber **126b** by a substantially constant distance. In the illustrated example, the forefoot interior chamber **128b** includes a necked portion **154** adjacent to the first end **150b**, which extends between the bulbous ends **138b**, **140b** of the forefoot peripheral chamber **126b**. The second end **152b** of the forefoot interior chamber **128b** may also be bulbous, and is circumscribed by the segments **132b**, **134b**, **136b** of the forefoot peripheral chamber **126b**.

The interior chambers **128a**, **128b** are attached to the respective peripheral chambers **126a**, **126b** by the web area **120**, such that each of the interior chambers **128a**, **128b** is surrounded by a portion the web area **120**. Accordingly, the web area **120** includes a first portion **153a** having a substantially U-shape surrounding the heel interior chamber **128a**, and a second portion **153b** having a substantially U-shape surrounding the forefoot interior chamber **128b**. As shown, the first U-shaped portion **153a** of the web area **120** extends between and attaches the outer perimeter of the heel interior chamber **128a** and the inner perimeter of the heel perimeter chamber **126a**. Likewise, the second U-shaped portion **153b** extends between and attaches the outer perimeter of the forefoot interior chamber **128b** and the inner perimeter of the forefoot perimeter chamber **126b**. As illustrated, with respect to the aforementioned portions of the web area **120**, the term “U-shaped” is not limited strictly to shapes having two straight legs connected by a constant curvature, but instead refers to any shape that extends from a first end along a general first direction, and then turns back and extends along the first direction to a second end adjacent to or across from the first end. For example, the respective ends of the first U-shaped portion **153a** and the second U-shaped portion **153b** may extend away from one another. Thus, the U-shaped portions of the web area could also be described as being horseshoe-shaped, bell-shaped, or hair-pin-shaped, for example.

Adjacent ones of the chambers **126a-126c**, **128a-128b** are separated from each other by the portions of the web area **120**, such that pockets or spaces **158a-158c**, **160a-160c** are formed on opposite sides **114**, **116** of the bladder **106** between adjacent ones of the chambers **126a-126c**, **128a-128b**, as best shown in FIGS. 6-8. In other words, the bladder **106** includes a series of upper pockets **158a-158c** formed by the web area **120** and adjacent chambers **126a-126c**, **128a-128b** on the top side **114** of the bladder **106**, and a series of lower pockets **160a-160c** formed by the web area **120** and adjacent chambers **126a-126c**, **128a-128b** on the bottom side **116** of the bladder **106**.

With continued reference to FIG. 5, the bladder **106** includes a plurality of conduits **162a-162d** fluidly coupling adjacent ones of the peripheral chambers **126a-126c** to each other. Accordingly, the portions of the interior void **130** formed by each of the peripheral chambers **126a-126c** are in fluid communication with each other, such that fluid can be transferred between the peripheral chambers **126a-126c**. In the illustrated example, a first pair of conduits **162a**, **162b** connects the ends **138a**, **140a** of the heel peripheral chamber **126a** to the intermediate segment **136b** of the forefoot peripheral chamber **126b**, and a second pair of conduits **162c**, **162d** connects the ends **138b**, **140b** of the forefoot peripheral chamber **126b** to the intermediate segment **136c** of the toe peripheral chamber **126c**.



With continued reference to FIG. 2, the chassis 108 is configured to interface with the bladder 106 to provide a unitary midsole 102. The chassis 108 extends from a first end 164 at the anterior end 18 of the sole structure 100 to a second end 166 at the posterior end 20 of the sole structure 100. The chassis 108 further includes a top surface 168 defining a portion of a footbed, and a bottom surface 170 formed on the opposite side of the chassis 108 than the top surface 168 and configured to interface with the top side 114 of the bladder 106.

The chassis 108 includes a plurality of projections 172a-172c formed on the bottom surface 170. Here, a shape each of the projections 172a-172c corresponds to a shape one of the upper pockets 158a-158c formed in the bladder 106, such that when the chassis 108 is assembled with the bladder 106, one of the projections 172a-172c is received within a respective one of the upper pockets 158a-158c. In the illustrated example, the projections 172a-172c are configured to fully extend into the upper pockets 158a-158c when the midsole 102 is assembled. Thus, distal ends 174a-174c of each of the projections 172a-172c contact the web area 120. In other examples, one or more of the projections 172a-172c may be configured so that the distal ends 174a-174c are spaced apart from the web area 120, or may be omitted from the chassis.

As described above, the chassis 108 is formed of a resilient polymeric material, such as foam or rubber, to impart properties of cushioning, responsiveness, and energy distribution to the foot of the wearer. The chassis 108 may independently be formed from a single unitary piece of resilient polymeric material, or may be formed of a plurality of elements each formed of one or more resilient polymeric materials. For example, the plurality of elements may be affixed to each other using a fusing process, using an adhesive, or by suspending the elements in a different resilient polymeric material. Alternatively, the plurality of elements may not be affixed to each other, but may remain independent while contained in one or more structures forming the cushioning element. In this alternative example, the plurality of independent cushioning elements may be a plurality of foamed particles, and may be contained in a bladder or shell structure. As such, the cushioning element may be formed of a plurality of foamed particles contained within a relatively translucent bladder or shell formed of a film such as a barrier membrane.

Example resilient polymeric materials for the chassis may include those based on foaming or molding one or more polymers, such as one or more elastomers (e.g., thermoplastic elastomers (TPE)). The one or more polymers may include aliphatic polymers, aromatic polymers, or mixtures of both; and may include homopolymers, copolymers (including terpolymers), or mixtures of both.

In some aspects, the one or more polymers may include olefinic homopolymers, olefinic copolymers, or blends thereof. Examples of olefinic polymers include polyethylene, polypropylene, and combinations thereof. In other aspects, the one or more polymers may include one or more ethylene copolymers, such as, ethylene-vinyl acetate (EVA) copolymers, EVOH copolymers, ethylene-ethyl acrylate copolymers, ethylene-unsaturated mono-fatty acid copolymers, and combinations thereof.

In further aspects, the one or more polymers may include one or more polyacrylates, such as polyacrylic acid, esters of polyacrylic acid, polyacrylonitrile, polyacrylic acetate, polymethyl acrylate, polyethyl acrylate, polybutyl acrylate,

polymethyl methacrylate, and polyvinyl acetate; including derivatives thereof, copolymers thereof, and any combinations thereof.

In yet further aspects, the one or more polymers may include one or more ionomeric polymers. In these aspects, the ionomeric polymers may include polymers with carboxylic acid functional groups, sulfonic acid functional groups, salts thereof (e.g., sodium, magnesium, potassium, etc.), and/or anhydrides thereof. For instance, the ionomeric polymer(s) may include one or more fatty acid-modified ionomeric polymers, polystyrene sulfonate, ethylene-methacrylic acid copolymers, and combinations thereof.

In further aspects, the one or more polymers may include one or more styrenic block copolymers, such as acrylonitrile butadiene styrene block copolymers, styrene acrylonitrile block copolymers, styrene ethylene butylene styrene block copolymers, styrene ethylene butadiene styrene block copolymers, styrene ethylene propylene styrene block copolymers, styrene butadiene styrene block copolymers, and combinations thereof.

In further aspects, the one or more polymers may include one or more polyamide copolymers (e.g., polyamide-polyether copolymers) and/or one or more polyurethanes (e.g., cross-linked polyurethanes and/or thermoplastic polyurethanes). Examples of suitable polyurethanes include those discussed above for barrier layers 118. Alternatively, the one or more polymers may include one or more natural and/or synthetic rubbers, such as butadiene and isoprene.

When the resilient polymeric material is a foamed polymeric material, the foamed material may be foamed using a physical blowing agent which phase transitions to a gas based on a change in temperature and/or pressure, or a chemical blowing agent which forms a gas when heated above its activation temperature. For example, the chemical blowing agent may be an azo compound such as azodicarbonamide, sodium bicarbonate, and/or an isocyanate.

In some embodiments, the foamed polymeric material may be a crosslinked foamed material. In these embodiments, a peroxide-based crosslinking agent such as dicumyl peroxide may be used. Furthermore, the foamed polymeric material may include one or more fillers such as pigments, modified or natural clays, modified or unmodified synthetic clays, talc glass fiber, powdered glass, modified or natural silica, calcium carbonate, mica, paper, wood chips, and the like.

The resilient polymeric material may be formed using a molding process. In one example, when the resilient polymeric material is a molded elastomer, the uncured elastomer (e.g., rubber) may be mixed in a Banbury mixer with an optional filler and a curing package such as a sulfur-based or peroxide-based curing package, calendared, formed into shape, placed in a mold, and vulcanized.

In another example, when the resilient polymeric material is a foamed material, the material may be foamed during a molding process, such as an injection molding process. A thermoplastic polymeric material may be melted in the barrel of an injection molding system and combined with a physical or chemical blowing agent and optionally a crosslinking agent, and then injected into a mold under conditions which activate the blowing agent, forming a molded foam.

Optionally, when the resilient polymeric material is a foamed material, the foamed material may be a compression molded foam. Compression molding may be used to alter the physical properties (e.g., density, stiffness and/or durometer) of a foam, or to alter the physical appearance of the foam (e.g., to fuse two or more pieces of foam, to shape the foam, etc.), or both.



The compression molding process desirably starts by forming one or more foam preforms, such as by injection molding and foaming a polymeric material, by forming foamed particles or beads, by cutting foamed sheet stock, and the like. The compression molded foam may then be made by placing the one or more preforms formed of foamed polymeric material(s) in a compression mold, and applying sufficient pressure to the one or more preforms to compress the one or more preforms in a closed mold. Once the mold is closed, sufficient heat and/or pressure is applied to the one or more preforms in the closed mold for a sufficient duration of time to alter the preform(s) by forming a skin on the outer surface of the compression molded foam, fuse individual foam particles to each other, permanently increase the density of the foam(s), or any combination thereof. Following the heating and/or application of pressure, the mold is opened and the molded foam article is removed from the mold.

In some examples, the outsole **104** extends over the midsole **102** to provide increased durability and resiliency. In the illustrated example, the outsole **104** is provided as a polymeric layer that is overmolded onto the bladder **106** to provide increased durability to the exposed portions of the lower barrier layer **118** of the bladder **106**. Accordingly, the outsole **104** is formed of a different material than the bladder **106**, and includes at least one of a different thickness, a different hardness, and a different abrasion resistance than the lower barrier layer **118**. In some examples, the outsole **104** may be formed integrally with the lower barrier layer **118** of the bladder **106** using an overmolding process. In other examples, the outsole **104** may be formed separately from the lower barrier layer **118** of the bladder **106** and may be adhesively bonded to the lower barrier layer **118**.

The upper **200** is attached to the sole structure **100** and includes interior surfaces that define an interior void configured to receive and secure a foot for support on sole structure **100**. The upper **200** may be formed from one or more materials that are stitched or adhesively bonded together to form the interior void. Suitable materials of the upper may include, but are not limited to, mesh, textiles, foam, leather, and synthetic leather. The materials may be selected and located to impart properties of durability, air-permeability, wear-resistance, flexibility, and comfort.

The following Clauses provide exemplary configurations for a bladder, a sole structure, and an article of footwear described above.

Clause 1. A bladder comprising a first chamber having a substantially U-shape and a second chamber having a substantially U-shape and being spaced apart from the first chamber in a direction extending along a longitudinal axis of the bladder.

Clause 2. The bladder of Clause 1, wherein the first chamber and the second chamber are in fluid communication with one another.

Clause 3. The bladder of any of the preceding Clauses, wherein the first chamber is aligned with the second chamber.

Clause 4. The bladder of any of the preceding Clauses, wherein the first chamber includes a first leg and a second leg joined by a first arcuate segment and the second chamber includes a third leg and a fourth leg joined by a second arcuate segment.

Clause 5. The bladder of Clause 4, wherein the first leg, the second leg, the third leg, and the fourth leg extend in the same direction.

Clause 6. The bladder of Clause 4 or Clause 5, wherein the first leg and the second leg are disposed between the first arcuate segment and the second arcuate segment.

Clause 7. The bladder of any of Clauses 4-6, wherein at least one of the first leg, the second leg, the third leg, and the fourth leg is elongate.

Clause 8. The bladder of any of Clauses 4-7, further comprising a third chamber extending between the first leg and the second leg in a direction toward the first arcuate segment.

Clause 9. The bladder of Clause 8, wherein the third chamber is spaced apart from the first leg and the second leg.

Clause 10. The bladder of any of Clauses 4-9, further comprising a fourth chamber extending between the third leg and the fourth leg in a direction toward the second arcuate segment.

Clause 11. The bladder of Clause 10, wherein the fourth chamber is spaced apart from the third leg and the fourth leg.

Clause 12. The bladder of Clause 10 or Clause 11, wherein at least one of the third chamber and the fourth chamber is elongate.

Clause 13. The bladder of any of the preceding Clauses, further comprising a web area defining the first chamber and the second chamber.

Clause 14. The bladder of Clause 13, wherein the web area includes a first portion having a substantially U-shape and a second portion having a substantially U-shape.

Clause 15. An article of footwear incorporating the bladder of any of the preceding Clauses.

Clause 16. A bladder comprising a first chamber, a second chamber spaced apart from the first chamber in a direction extending along a longitudinal axis of the bladder, and a web area defining the first chamber and the second chamber and including a first portion having a substantially U-shape and a second portion having a substantially U-shape.

Clause 17. The bladder of Clause 16, wherein the first chamber and the second chamber are in fluid communication with one another.

Clause 18. The bladder of Clause 16, wherein the first chamber includes a substantially U-shape and the second chamber includes a substantially U-shape, the first chamber being aligned with the second chamber.

Clause 19. The bladder of any of the preceding Clauses, wherein the first chamber includes a first leg and a second leg joined by a first arcuate segment and the second chamber includes a third leg and a fourth leg joined by a second arcuate segment.

Clause 20. The bladder of Clause 19, wherein the first leg, the second leg, the third leg, and the fourth leg extend in the same direction.

Clause 21. The bladder of Clause 19 or Clause 20, wherein the first leg and the second leg are disposed between the first arcuate segment and the second arcuate segment.

Clause 22. The bladder of any of Clauses 19-21, wherein at least one of the first leg, the second leg, the third leg, and the fourth leg is elongate.

Clause 23. The bladder of any of Clauses 19-22, further comprising a third chamber extending between the first leg and the second leg in a direction toward the first arcuate segment.

Clause 24. The bladder of Clause 23, wherein the third chamber is spaced apart from the first leg and the second leg.

Clause 25. The bladder of any of Clauses 19-24, further comprising a fourth chamber extending between the third leg and the fourth leg in a direction toward the second arcuate segment.



Clause 26. The bladder of Clause 25, wherein the fourth chamber is spaced apart from the third leg and the fourth leg.

Clause 27. The bladder of Clause 25 or Clause 26, wherein at least one of the third chamber and the fourth chamber is elongate.

Clause 28. An article of footwear incorporating the bladder of any of the preceding Clauses.

The foregoing description has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular configuration are generally not limited to that particular configuration, but, where applicable, are interchangeable and can be used in a selected configuration, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

What is claimed is:

1. A bladder comprising:

a first chamber having a first arcuate portion joining a first medial leg and a first lateral leg that cooperate with the first arcuate portion to provide the first chamber with a substantially U-shape;

a first web area including a first leg extending along the first medial leg and including a first distal end, a second leg extending along the first lateral leg and including a second distal end, and an arcuate portion extending between and connecting the first leg and the second leg, the first distal end and the second distal end extending away from one another;

a second chamber having a second arcuate portion joining a second medial leg extending along a medial side of the bladder and forming a portion of a medial-most edge of the bladder and a second lateral leg extending along a lateral side of the bladder and forming a portion of a lateral-most edge of the bladder, the second medial leg and the second lateral leg cooperating with the second arcuate portion to provide the second chamber with a substantially U-shape; and

a second web area including a third leg extending along the second medial leg, a fourth leg extending along the second lateral leg, and an arcuate portion extending between and connecting the third leg and the fourth leg, the arcuate portion of the second web area spaced forward from the first distal end of the first web area and the second distal end of the first web area in a direction along a longitudinal axis of the bladder.

2. The bladder of claim 1, wherein the third leg includes a third distal end and the fourth leg includes a fourth distal end.

3. The bladder of claim 2, wherein the third distal end and the fourth distal end extend away from one another.

4. The bladder of claim 1, wherein at least one of the first medial leg and the first lateral leg includes a first lobe and a second lobe separated from the first lobe by a first depression defined by a portion of the at least one of the first medial leg and the first lateral leg extending between the first lobe and the second lobe.

5. The bladder of claim 4, wherein the first depression has a smaller cross-sectional area than the first lobe and the second lobe.

6. The bladder of claim 1, wherein the first medial leg, the first lateral leg, the second medial leg, and the second lateral leg respectively extend away from the first arcuate portion and the second arcuate portion in a same direction.

7. The bladder of claim 1, wherein the first medial leg, the first lateral leg, the second medial leg, and the second lateral leg respectively extend away from the first arcuate portion and the second arcuate portion in a direction substantially parallel to the longitudinal axis of the bladder.

8. A sole structure incorporating the bladder of claim 1.

9. An article of footwear incorporating the bladder of claim 1.

10. A bladder comprising:

a first chamber having a first arcuate portion joining a first medial leg and a first lateral leg that cooperate with the first arcuate portion to provide the first chamber with a substantially U-shape;

a first web area including a first leg extending along the first medial leg, a second leg extending along the first lateral leg, and an arcuate portion extending between and connecting the first leg and the second leg, the first web area including a substantially U-shape;

a second chamber having a second arcuate portion joining a second medial leg extending along a medial side of the bladder and forming a portion of a medial-most edge of the bladder and a second lateral leg extending along a lateral side of the bladder and forming a portion of a lateral-most edge of the bladder, the second medial leg and the second lateral leg cooperating with the second arcuate portion to provide the second chamber with a substantially U-shape; and

a second web area including a third leg extending along the second medial leg, a fourth leg extending along the second lateral leg, and an arcuate portion extending between and connecting the third leg and the fourth leg, the arcuate portion of the second web area spaced forward from the first leg of the first web area and the second leg of the first web area in a direction along a longitudinal axis of the bladder.

11. The bladder of claim 10, wherein the second web area includes a substantially U-shape.

12. The bladder of claim 10, wherein at least one of the first medial leg and the first lateral leg includes a first lobe and a second lobe separated from the first lobe by a first depression defined by a portion of the at least one of the first medial leg and the first lateral leg extending between the first lobe and the second lobe.

13. The bladder of claim 12, wherein the first depression has a smaller cross-sectional area than the first lobe and the second lobe.

14. The bladder of claim 10, wherein the first medial leg, the first lateral leg, the second medial leg, and the second lateral leg respectively extend away from the first arcuate portion and the second arcuate portion in a same direction.

15. The bladder of claim 10, wherein the first medial leg, the first lateral leg, the second medial leg, and the second lateral leg respectively extend away from the first arcuate portion and the second arcuate portion in a direction substantially parallel to the longitudinal axis of the bladder.

16. A sole structure incorporating the bladder of claim 10.

17. An article of footwear incorporating the bladder of claim 10.